CHAPTER 2

DISPOSAL SITE USE AND MONITORING

A. DISPOSAL ACTIVITY AND SITE USE

The Washington Department of Natural Resources (DNR) issues site-use authorizations to project proponents who wish to dispose of dredged material at PSDDA, Grays Harbor/Willapa Bay and Columbia River open-water disposal sites. These authorizations are issued for sediments which are 1) suitable for open-water disposal as determined by the DMMP evaluation process; and 2) associated with dredging projects which have received all required regulatory permits (e.g., CWA 404/401 permits). This section of the report describes the PSDDA and Grays Harbor disposal activities for DY 1996 and 1997. Disposal site activity summaries for the Columbia River are not included in this report, but will be included in future Biennial Reports. Disposal activities are discussed by year and by individual disposal site.

Dredging Year 1996 (June 16, 1995 - June 15, 1996)

In DY96, a total of 935,056 cubic yards was disposed at six PSDDA sites, whereas a total of 1,998,047 cubic yards was disposed at two Grays Harbor sites and one beneficial use site in Half Moon Bay (Tables 2-1 and 2-2). Of the PSDDA sites, Commencement Bay, Rosario Strait and Port Gardner received the majority of the material, with totals of 460,684 cy, 205,500 cy, and 121,246 cy respectively. In Grays Harbor, the South Jetty estuarine site received the bulk of the material with 1,674,267 cy. Figures 2-1 and 2-2 illustrate the pattern of site use in DY96 for both PSDDA sites and Grays Harbor sites, respectively. Table 2-2 provides a project by project summary of the disposal activity for both PSDDA and Grays Harbor sites.

Table 2-1. Open-water Disposal Summary DY96

Disposal Site	Disposal Jurisdiction	# of Projects	Total Volume (cubic yards)
Commencement Bay	PSDDA	1	460,684
Elliott Bay	PSDDA	3	95,302
Port Gardner	PSDDA	1	121,246
Rosario Straits	PSDDA	2	205,500
Bellingham Bay	PSDDA	1	44,800
Port Angeles	PSDDA	1	22,344
Point Chehalis	Grays Harbor	4	370,203
South Jetty	Grays Harbor	1	1,674,267
Half Moon Bay (beneficial uses)	Grays Harbor	1	274,780
All Sites within Jurisdiction Combined:	PSDDA	9	935,056
	Grays Harbor	4	2,319,250

Table 2-2. Summary of DY96 Disposal Projects

Site	Proponent	Dredging Contractor	Disposal Volumes, cy	# Barge Loads	Off Site	Disposal Dates
CB	Port of Tacoma West Blair .	Fletcher General	460,684	330	no	11/02/95 to 03/14/96
EB	City of Bremerton Warren Ave. Outfall	A. H. Powers	2,500	3	no	06/23/95 to 07/20/95
EB	Sinclair Inlet Marina	Manson Construction	2,745	6	no	07/17/95 to 07/22/95
EB	USACE, Duwamish O&M	J.E. McAmis	90,057[1]	55	no	02/14/96 to 03/30/96
PG	Port of Everett Pier I South	A. H. Powers	121,246	69	no	07/24/95 to 10/02/95
BB	USACE / POB (local sponsor), Squalicum Waterway O&M	J.E. McAmis	44,800	27	no	09/30/95 to 10/20/95
RS	Port of Bellingham (POB)/Bellingham Cold Storage	J.E. McAmis	39,000	26	no	09/30/95 to 01/28/96
RS	USACE / POB (local sponsor), Squalicum Waterway	J.E. McAmis	166,500	111	no	09/30/95 to 01/28/96
PA	Holnam Inc./ Ideal Cement	American Construction	22,344	19	no	02/02/96 to 02/22/96
PC	Weyerhaeuser Bay	Great Lakes	6,000	2	no	06/16/95

[1] Includes 14,820 cubic yards of material that was placed within the southwest corner of the site to cap material from a previous Corps/Waterways Experiment Station experimental disposal of 114,000 cubic meters of PCB contaminated material during the late 1970s (Pavlou et. al. 1977).

	City Dock					
PC	Rayonier Inc.	Great Lakes	19,800	6	no	06/20/95
PC	Port of Grays Harbor Terminal 2	Great Lakes	48,684	14	no	06/18/95 to 06/20/95
PC	USACE, Grays Harbor O&M	Great Lakes	295,719	43	no	09/01/96 to 09/09/96
SJ	USACE, Grays Harbor O&M	Great Lakes	1,634,517	586	no	04/30/96 to 08/31/96
SJ	USACE, Grays Harbor O&M	USACE Hopper Dredge "YAQUINA"	6,375	~24	no	05/07/96 to 05/11/96
SJ	USACE, Grays Harbor O&M	USACE Hopper Dredge "YAQUINA"	33,375	~40	no	05/04/96 to 05/30/96
HMB	USACE, Grays Harbor O&M	USACE Hopper Dredge "YAQUINA"	274,780	~330	no	05/04/96 to 05/30/96

Legend: EB = Elliott Bay; PG = Port Gardner; CB = Commencement Bay; PA = Port Angeles; BB = Bellingham Bay; RS = Rosario Strait; PC = Point Chehalis; SJ = South Jetty; HMB = Half Moon Bay

Dredging Year 1997 (June 16, 1996 - June 15, 1997)

In DY97, a relatively small total volume of 121,513 cy was disposed at two PSDDA disposal sites, whereas a total volume of 1,933,241 cy was disposed at the two Grays Harbor estuarine disposal sites and at one beneficial use site in Half Moon Bay (Table 2-3). Of the PSDDA sites, only Elliott Bay and Port Gardner were used, receiving volumes of 18,982 cy and 102,531 cy, respectively. In Grays Harbor, both the South Jetty site and the Point Chehalis site had relatively heavy use with 959,249 cy and 665,388 cy respectively. Figures 2-3 and 2-4 illustrate the pattern of site use in DY97 for both PSDDA sites and Grays Harbor sites, respectively. Table 2-4 provides a project-by-project summary of the disposal activity at both PSDDA and Grays Harbor sites.

Table 2-3. Openwater Disposal Activity Summary DY97

Disposal Site	Disposal Jurisdiction	# of Projects	Total Volume (cubic yards)
Elliott Bay	PSDDA	5	18,982
Port Gardner	PSDDA	1	102,531
Point Chehalis	Grays Harbor	5	665,388
South Jetty	Grays Harbor	1	959,249
Half Moon Bay (beneficial uses)	Grays Harbor	1	308,604
All Sites within Jurisdiction Combined:	PSDDA	6	121,513
	Grays Harbor	5	1,933,241

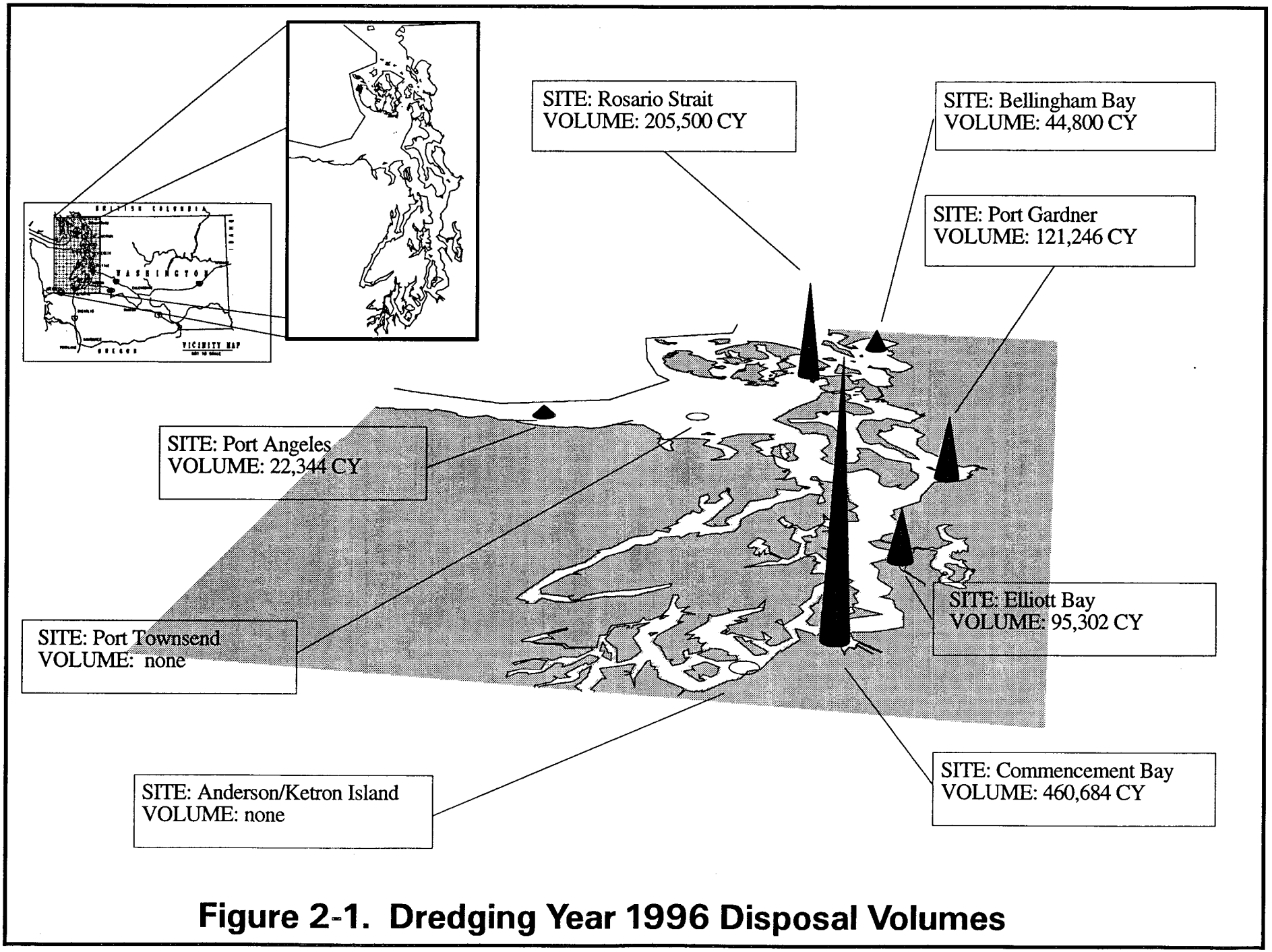

Figure 2-1. Dredging Year 1996 Disposal Volumes

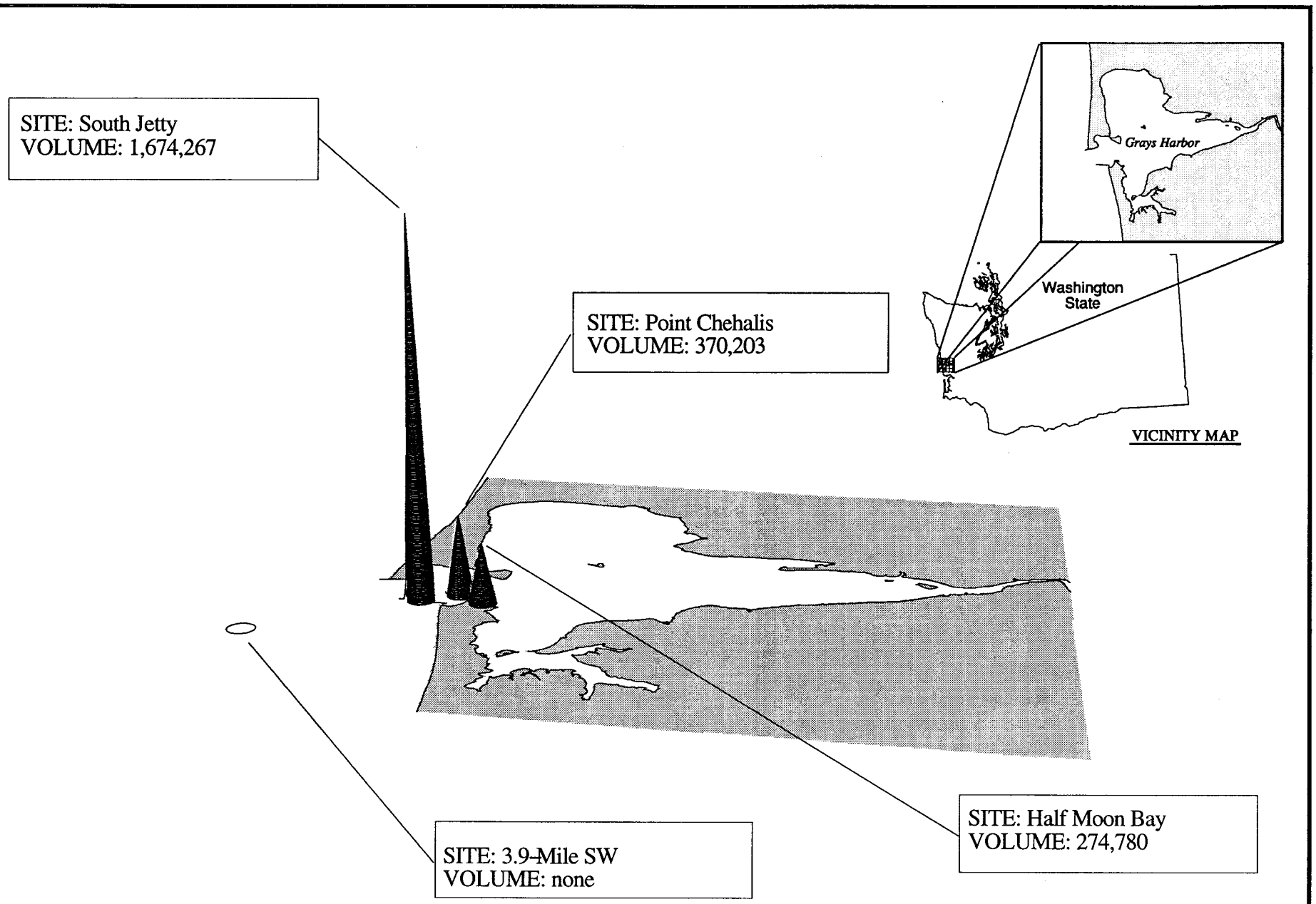

Figure 2-2. Dredging Year 1996 Disposal Volumes for Grays Harbor

Table 2-4. Summary of DY97 Disposal Projects

Site	Proponent	Dredging Contractor	Disposal Volumes, cy	# Barge Loads	Off Site	Disposal Dates
EB	Lone Star NW Kaiser Dock	A.H. Powers	12,070	7	no	06/24/96 to 07/02/96
EB	City of Kirkland Marina Park Boat Launch	A.H. Powers	800	1	no	10/25/96
EB	Crowley Marine Services	American Construction	2,400	2	no	12/27/96 to 12/28/96
EB	Port of Seattle	A.H. Powers	3,493	4	no	03/10/97 to 03/12/97
EB	Sinclair Inlet Marina	Island Tug and Barge	219	1	no	02/11/97
PG	Port of Everett Marine Terminal	A. H. Powers	102,531	92	no	11/11/96 to 03/12/97
PC	Weyerhaeuser, Bay City Dock	Great Lakes Dredge	14,000	4	no	08/18/96 to 02/25/97
PC	Port of Grays Harbor, T2	American Construction	38,500	12	no	07/01/96 to 07/16/96
PC	Rayonier, Inc.	Foss Engineering	20,000	6	no	02/22/97 to 02/23/97
PC	Port of Grays Harbor, T2	Great Lakes	14,173	6	no	02/24/97 to 02/25/97
PC	USACE Grays Harbor O&M	Manson Construction	218,666	215	no	04/23/97 to 5/8/97
PC	USACE Grays Harbor O&M	Manson Construction	360,049	139	no	04/15/97 to 06/13/97
SJ	USACE Grays Harbor O&M	Manson Construction	959,249	370	no	03/11/97 to 08/19/97
HMB	USACE Grays Harbor O&M	Manson Construction	172,923	126	no	04/07/97 to 05/07/97
HMB	USACE Grays Harbor O&M	USACE Hopper Dredge "YAQUINA"	135,686	~159	no	05/20/97 to 05/31/97

Legend:
EB = Elliott Bay; PC = Point Chehalis; SJ = South Jetty Site; HMB = Half Moon Bay

Summary of Disposal Activity by Jurisdiction and Site

PSDDA

Bellingham Bay. The Bellingham Bay open-water disposal site received 44,800 cy of dredged material from 1 project in DY96 (Table 2-1). This project was the Port of Bellingham/Corps of Engineers maintenance dredging in Squalicum Waterway. The work was accomplished by clamshell dredge, and all disposals occurred on site.

During DY97, there were no disposals at the Bellingham Bay site.

Port Gardner. During DY96, the Port Gardner disposal site received 121,246 cy of material from one project, the Port of Everett's Pier 1 South development project (Table 2-1). Although

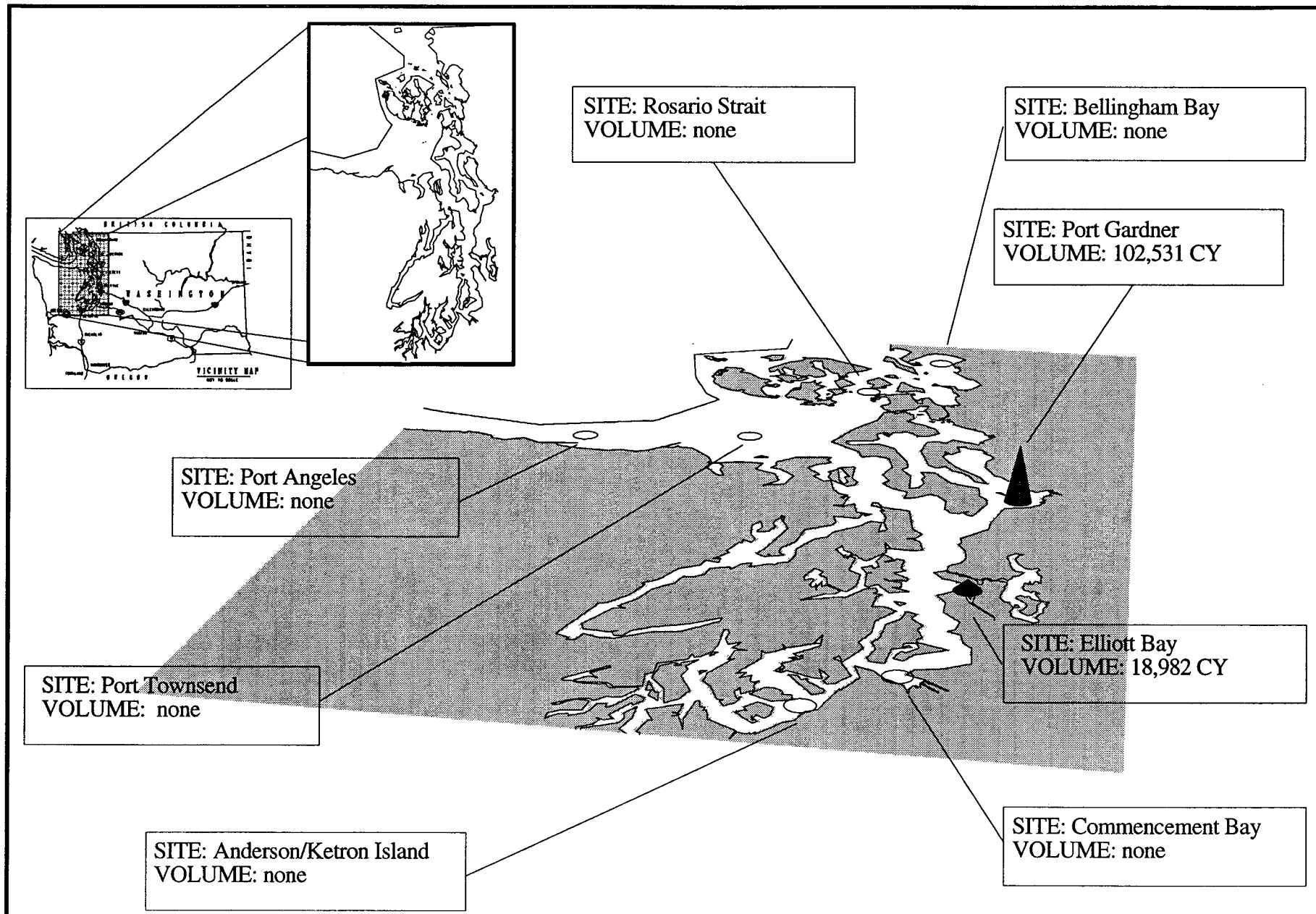

Figure 2-3. Dredging Year 1997 Disposal Volumes

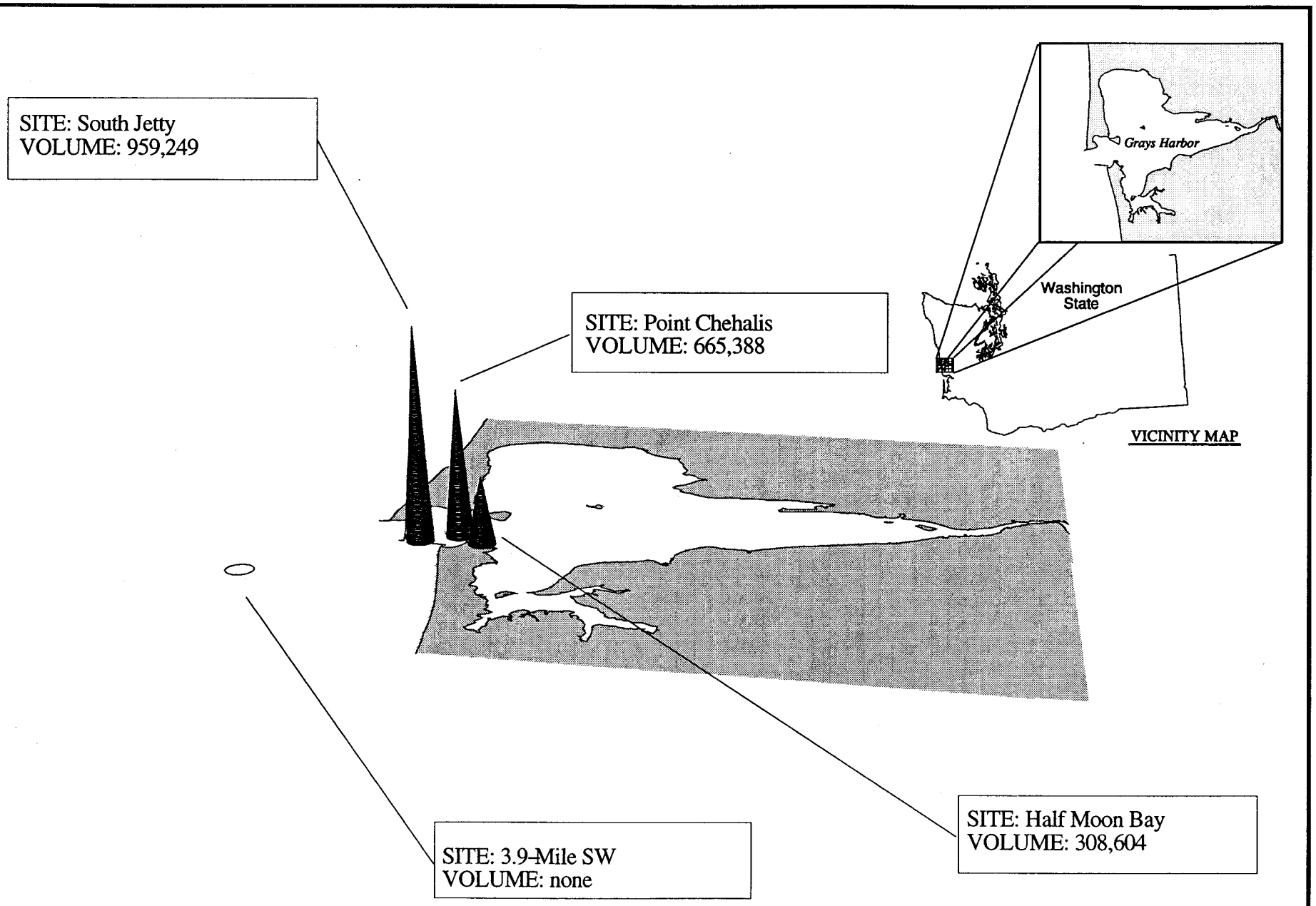

Figure 2-4. Dredging Year 1997 Disposal Volumes for Grays Harbor

all disposal occurred in the disposal area, the Port of Everett was assessed penalties for disposals in excess of the authorized volume of 105,000 cubic yards. All dredging was done by clamshell dredge.

In DY97, the Port Gardner site received 102,531 cy of material dredged from the Port of Everett's Stage 1 Marine Terminal Development project (Table 2-3). All dredging was done by clamshell dredge, and all disposals occurred within the target area.

Rosario Strait. During DY96, 205,500 cy of dredged material was disposed at the Rosario Strait disposal site, from two different, although related, projects (Table 2-1). These were the Corps of Engineers maintenance dredging of Squalicum Waterway and the dredging at Bellingham Cold Storage. All dredging was done by clamshell, and all disposals were on-site.

There were no disposals at the Rosario Strait site in DY97.

Elliott Bay. The Elliott Bay disposal site had a total of 95,302 cy of dredged material disposed during DY96 (Table 2-1). This was from 3 different projects: 2,500 cy from the City of Bremerton Warren Avenue stormwater outfall project, 2,745 cy from Sinclair Inlet Marina, and 90,057 from the Corps of Engineers Duwamish maintenance dredging project. All dredging was done by clamshell, and all disposals occurred on site.

During DY97, five projects disposed a total of 23,082 cy of clamshell dredged material at the Elliott Bay site (Table 2-3). These 5 projects were: 12,070 cy from Lonestar Northwest; 2,400 cy from the Crowley Marine Services; 878 cy from the City of Kirkland's Marina Park project; 3,493 cy from the Port of Seattle's Terminal 5 deepening; and 219 cy from Sinclair Inlet Marina.

Grays Harbor/Willapa Bay

Point Chehalis. During DY96, Point Chehalis received 370,203 cubic yards from four projects (Table 2-1). The four projects were the Weyerhaeuser project of 6,000 cy, the Rayonier project of 19,800 cy, the Port of Grays Harbor project of 48,684 cy, and the Corps of Engineers project of 295,719 cy. There were no offsite disposals.

During DY97, there was a total of 665,388 cy of dredged material disposed at the Point Chehalis site, from six projects (Tables 2-3 and 2-4). Again, there were no offsite disposals.

South Jetty. South Jetty was the site of disposals totaling 1,674,267 cy during DY96. The entire volume was from the Corps of Engineers maintenance dredging of Grays Harbor (Table 2-1). The disposals were, however, from three projects, of 1,634,517 cy, 6,375 cy, and 33,375 cy. The last two volumes were disposed from the hopper dredge YAQUINA.

In DY97, there was one project disposing of material at the South Jetty, a Corps of Engineers project of 959,249 cy.

B. PSDDA Disposal Site Monitoring

Overview.

Environmental monitoring is the primary tool in the management plan of the PSDDA non-dispersive disposal sites. The objective of disposal site monitoring is to determine whether the disposed dredged material is producing unanticipated adverse effects at the sites. Environmental monitoring can include physical, chemical, and biological assessment of the sediments and biological resources in and adjacent to the disposal sites. The PSDDA monitoring program is designed to compare the post-disposal monitoring results to "baseline" values. Baseline values of key environmental parameters, such as sediment chemistry, toxicity, and biological community structure, were determined for each PSDDA site and at various benchmark stations prior to the first use of the sites (PTI, 1988, 1989).

A post-disposal site monitoring survey is designed to answer three major questions:

1. Is the dredged material deposited on site?

2. Is the deposited dredged material producing chemical and/or biological conditions on site beyond the "minor adverse effects" levels allowed by the PSDDA site management plans?

3. Is the dredged material causing any adverse impacts to biological resources beyond the disposal site boundaries?

Full PSDDA monitoring is designed to address all three questions whereas partial PSDDA monitoring only addresses questions 1 and 2.

DNR and the Corps are responsible for the physical (Corps) and chemical/biological (DNR) monitoring of the PSDDA non-dispersive disposal sites. This environmental monitoring is conducted, at irregular intervals, based on the "pattern" of disposal site use since the previous monitoring event. This pattern encompasses several important elements, such as volume and characteristics of the material disposed at a given site, the nature and recency of previous site monitoring data, and site-specific environmental concerns. Each spring, DMMP technical staff review the previous year's disposal activity and reach consensus on which site(s), if any, will be monitored and at what intensity.

The following sections summarize the partial survey at the Commencement Bay site, which was conducted during the spring of 1996.

DY96 - Commencement Bay - Partial Monitoring

Site Use and Monitoring History. A baseline (pre-disposal) survey of the Commencement Bay disposal site was conducted by the Department of Ecology in 1988 (PTI, 1988). A cumulative disposal volume from 1989 through 1995 of 325,953 cubic yards triggered a full monitoring survey in June 1995. The results of that survey were summarized in the 1996 Biennial Report. During the year following this monitoring event, an additional 460,684 cubic yards were disposed at the Commencement Bay site triggering the partial monitoring event in June 1996.

1996 Partial Monitoring Results. Three types of samples were collected during this monitoring survey: physical mapping (sediment vertical profile imagery), sediment chemistry, and sediment toxicity (bioassays). The major findings of this survey follow, organized according to the two major monitoring questions addressed by the survey.

1) Does the dredged material stay on-site?

A total of 174 images were collected at 66 stations during the sediment vertical profile survey (SVPS). Stations sampled during 1996 were similar to those sampled in 1995, with nine additional stations in 1996 to more fully delineate the dredged material footprint. The dredged material footprint was roughly triangular in shape, with the major axis oriented northwest to southeast, and the southeastern edge of the deposit extending beyond the site boundary and tracing the edge of the disposal site perimeter (Figure 2-5). Dredged material thicknesses measured within the disposal zone were greater than prism penetration, suggesting that the majority of the dredged material was placed on target. The thickness of the deposit of dredged material decreases with distance from the disposal zone, forming a thin 1-5 cm triangular apron as shown in Figure 2-5. The SVPS imagery confirmed that virtually all the recently deposited dredged material was confined within the disposal site perimeter (all dredged material measured at perimeter line was 0.5 cm or less in thickness), and therefore met the site management objective (no dredged material thicknesses greater than 3 cm at perimeter line). All measured SVPS parameters, including optical signature, grain size distribution, RPD (redox-potential-discontinuity), and OSI (organism-sediment-index) were all in general agreement as to the distribution and orientation of the dredged material.

Results of the thirteen sediment chemistry samples/analyses conducted within the dredged material footprint at one onsite and at twelve perimeter stations (there were three field replicate stations at each of the four perimeter stations) are summarized as follows. Metals were all below State Sediment Management Standards (SMS) and PSDDA screening level (SL) guidelines except lead, which slightly exceeded SL (e.g., highest concentration measured at 70 ppm) in one of three replicate samples at two of the four perimeter stations. However, the mean lead concentration at all four perimeter stations was below the SL. Few organic compounds were detected within the thirteen samples and all were all quantitated below the SMS and PSDDA SLs,

except phenol, which had a single exceedance of the SL (e.g., concentration measured at 190 ppm dry weight compared with PSDDA SL of 120 ppm) at one of the four perimeter stations. Two undetected chemicals (2-methylphenol and 1,2,4-trichlorobenzene) had detection limits that slightly exceeded the PSDDA SL, but not the SMS.[2]

Of the few detected organic chemicals, two low molecular weight polycyclic aromatic hydrocarbons (LPAHs), phenanthrene and 2-methylnaphthalene were detected in all 12 perimeter samples but not in the onsite station. A third LPAH, naphthalene, was detected in one of the twelve perimeter station samples. Five high molecular weight polycyclic aromatic hydrocarbons (HPAHs) were detected in perimeter station samples: fluoranthene (12 of 13 samples), pyrene (10 of 13 samples), chrysene (10 of 13 samples), benzo(b)fluoranthene (9 of 13 samples), benzo(a)anthracene (3 of 13 samples). Phenol and bis (2-ethylhexyl)phthalate were detected in most of the perimeter station samples. Aldrin was the only pesticide detected (1 of 13 samples).

In summary, the SVPS results indicated that the dredged material remained on site, as did the perimeter chemistry results (no exceedances of the State SMS sediment quality standards off-site).

2) Is the dredged material causing biological effects beyond the "minor adverse effects" allowed at the disposal site?

Onsite chemistry measurements indicated that there were no exceedances of the PSDDA MLs or state SMS at the one onsite station. Therefore, the chemical site management objective was not exceeded (all chemicals less than maximum levels).

The suite of PSDDA bioassays evaluated biological conditions at the one on-site location. All four bioassays passed the nondispersive site interpretive guidelines. Therefore, the biological effects management guideline ("minor adverse effects") for nondispersive sites was not exceeded.

Time Trend Analysis. Following the 1995 Commencement Bay monitoring survey, the PSDDA agencies decided to use the 1995 Commencement Bay data as baseline values for future monitoring comparisons in Commencement Bay. The rationale for this decision was documented in a 1997 PSDDA clarification paper presented at the Sediment Management Annual Review Meeting (Kendall and Benson, 1997). The results of a new time trend analysis approach implemented via this clarification paper are summarized below.

Technical Discussion. The DMMP agencies applied a new time trend statistical procedure to the 1996 Commencement Bay monitoring data to determine if changes observed in perimeter site chemistry were significant over time. The model applied is called the "Chemical Tracking System" (CTS), and is described in detail in SAIC (1996a). Briefly, the CTS evaluates the changes in site chemistry for each chemical, or for a guild of chemicals (e.g., metals, LPAHs), as a slope expressing the trend in concentrations over time. Underlying the approach is the assumption that if there is mass movement of dredged material, multiple chemicals will be involved and there will be a common trend among the chemical concentrations. The mean slope

[2] However, these values do not exceed 1998 SLs for phenol, 2-methylphenol and 1,2,4-trichlorobezene

of concentration versus time for several chemicals gives a more accurate estimate of change than use of the slopes of individual chemicals.

The CTS model was incorporated into an Excel spreadsheet, and run for Commencement Bay perimeter stations using the baseline (1988), 1995, and 1996 monitoring data (SAIC, 1996b). A brief discussion of the CTS outcome relative to time-trend analysis is included below.

All chemicals of concern (COCs). Table 2-5 presents the maximum likelihood estimations for each perimeter station; first as a global estimate for all COCs and then by individual groups. The analyses were based on the Puget Sound conventionals, metals, LPAHs and HPAHs, bis(2-ethylhexyl)phthalate and phenol. The remaining COCs were reported as unmeasured or undetected in the 1988, 1995, and 1996 surveys.

The global maximum likelihood results indicate that a significant ($p=0.05$) decrease occurred at one perimeter station (CBP01), but that there have been no significant changes in COCs at the remaining perimeter stations since 1988. For CBP01, there was a highly significant ($p<0.001$) mean decrease of 7.5% per year, largely caused by the decreases in LPAH and HPAH at all the perimeter stations. While metals showed significant increases, the overall trend at CBP01 was downward. Results of these analyses are discussed below based upon the major chemical groups.

Metals. As a group, the time trend analysis for three of the perimeter stations (CBP03, CBP07, and CBP11) did not demonstrate a significant change in metal concentrations over time. However, at one perimeter station (CBP01), examination of the slopes and p-values for arsenic, copper, mercury, silver and zinc showed significant positive increases since 1988. At all perimeter stations there were significant ($p<0.01$) increases in lead concentration.

PAHs. Time trend analysis suggests that there is a decreasing trend in perimeter PAH concentrations at CBP01, but LPAH changes at the other three perimeter stations were not significantly different from zero. For the LPAHs at CBP01 there were significant decreases in concentrations for five of the seven measured LPAHs since 1988; as much as 26% for acenapthene and anthracene. Even when comparing 1995 and 1996 CBP01 data, there are decreases in measured concentrations for all LPAHs. HPAHs show the same trend; a significant decrease at CBP01, but no significant changes at the other three perimeter stations.

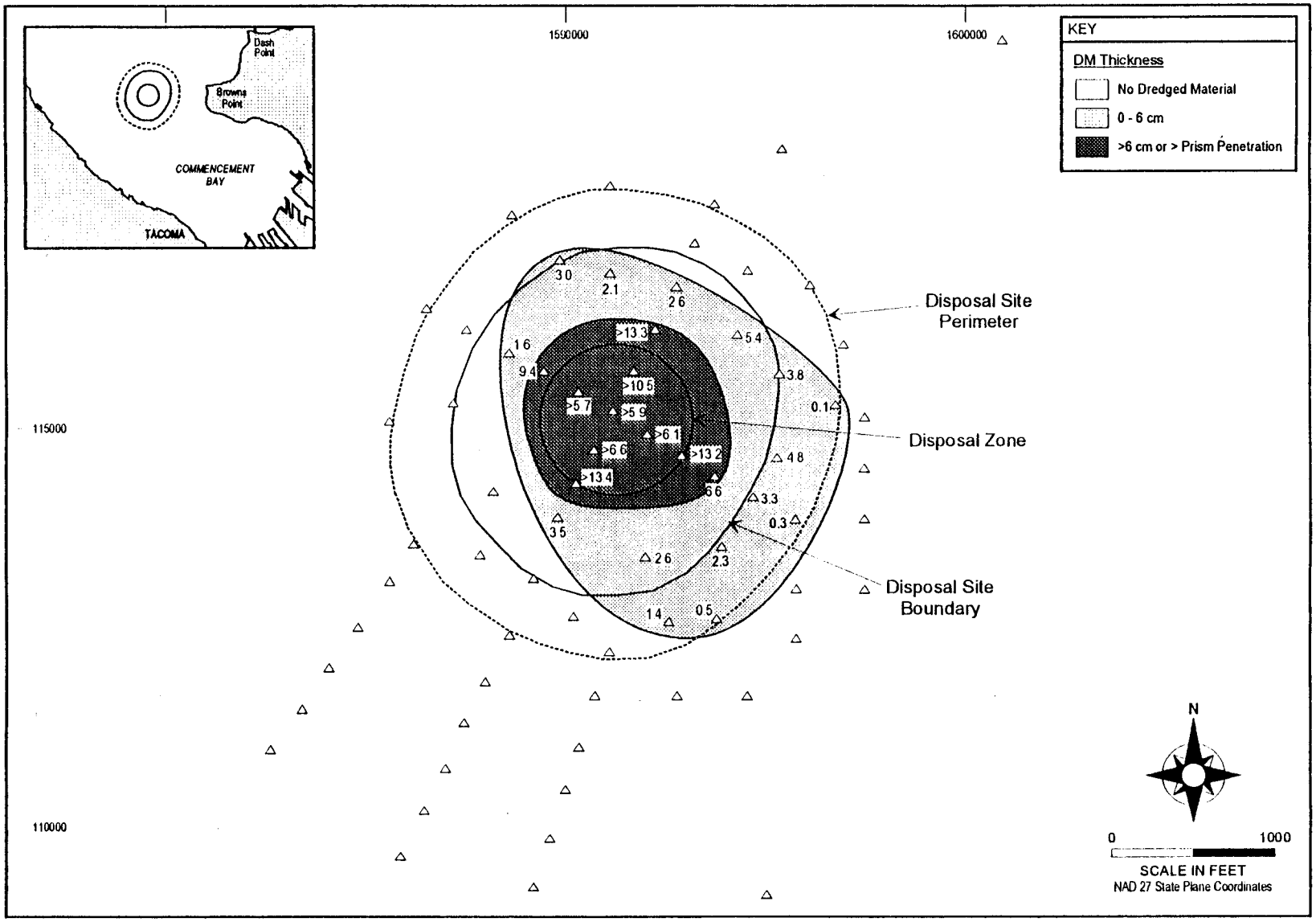

Figure 2-5. Dredged Material footprint measured at the Commencement Bay disposal site in 1996. Thickness is measured in centimeters.

Table 2-5. Sample Maximum Likelihood output for Commencement Bay perimeter stations. Results are presented as both global results, and by major chemical groups.

	SLOPE AND SIGNIFICANCE (Log 10)						***PERCENT CHANGE PER YEAR***		
	Mean	**S.E.**	**95% LCL**	**95% UCL**	**P-Value**		**Mean**	**95% LCL**	**95% UCL**
CBP01									
Global	-0.03385	0.00920	-0.05262	-0.01509	0.00088		-7.50	-11.41	-3.41
Conventionals	0.02569	0.00681	0.00817	0.04321	0.01302		6.09	1.90	10.46
Metals	0.02591	0.00410	0.01588	0.03593	0.00073		6.15	3.72	8.63
LPAH	-0.10661	0.01085	-0.14114	-0.07208	0.00224		-21.77	-27.75	-15.29
HPAH	-0.09456	0.02892	-0.16533	-0.02379	0.01705		-19.57	-31.66	-5.33
CBP03									
Global	-0.01737	0.01118	-0.04021	0.00547	0.13092		-3.92	-8.84	1.27
Conventionals	-0.02185	0.01757	-0.06484	0.02114	0.26000		-4.91	-13.87	4.99
Metals	-0.00690	0.00762	-0.02555	0.01174	0.39983		-1.58	-5.71	2.74
LPAH	-0.00334	0.01502	-0.06795	0.06127	0.84475		-0.77	-14.48	15.15
HPAH	-0.05841	0.03257	-0.14215	0.02532	0.13290		-12.58	-27.91	6.00
CBP07									
Global	-0.01556	0.00896	-0.03391	0.00280	0.09355		-3.52	-7.51	0.65
Conventionals	-0.03028	0.02185	-0.08376	0.02319	0.21511		-6.74	-17.54	5.48
Metals	-0.01564	0.00758	-0.03419	0.00292	0.08487		-3.54	-7.57	0.68
LPAH	0.03701	0.00894	-0.07655	0.15057	0.15084		8.90	-16.16	41.44
HPAH	-0.02557	0.01993	-0.07680	0.02566	0.25572		-5.72	-16.21	6.09
CBP11									
Global	-0.01984	0.01225	-0.04494	0.00526	0.11666		-4.47	-9.83	1.22
Conventionals	0.01874	0.01373	-0.01373	0.05122	0.21453		4.41	-3.11	12.52
Metals	-0.00850	0.01231	-0.03862	0.02163	0.51581		-1.94	-8.51	5.11
LPAH	-0.01914	0.01115	-0.16077	0.12249	0.33572		-4.31	-30.94	32.58
HPAH	-0.08118	0.03838	-0.17983	0.01747	0.08801		-17.05	-33.90	4.10

As a measure of decreases in PAHs at the perimeter stations, Table 2-6 compares mean total LPAH and HPAH concentrations in 1995 and 1996. In all cases, the 1996 perimeter PAH concentrations are less than those reported in 1995.

Table 2-6. Comparison of 1995 and 1996 total LPAH and HPAH concentrations at the perimeter stations. All values reported as µg/kg DW.

	CBP01		CBP03		CBP07		CBP11	
Year	**LPAH**	**HPAH**	**LPAH**	**HPAH**	**LPAH**	**HPAH**	**LPAH**	**HPAH**
1996	91	208	81	123	79	174	23	36
1995	297	2105	180	583	98	440	108	515

Summary: DMMP disposal site use and monitoring since program implementation

The cumulative dredged material volumes disposed at each PSDDA site and each Grays Harbor site since program implementation are depicted in Table 2-7 and Figures 2-6 and 2-7. All eight PSDDA sites have been used, and the two estuarine sites in Grays Harbor have been utilized. There was no disposal in DY96 and DY97 at the Willapa Bay disposal sites. Nine year summaries of site use for the PSDDA sites show that site capacities appear to be sufficient to last at least fifty years for most sites (Figure 2-6, Table 2-8). Over the nine years of PSDDA implementation (1989-1997) 4,441,924 cubic yards total have been placed at all eight open-water sites, averaging 551,241 cubic yards per year.

Table 2-7. Cumulative Site Use Summary.

Disposal Site	Dredging Years Used	Cumulative Volumes Disposed (cubic yards)
PSDDA	**(1989 - 1997)**	
Anderson/Ketron (ND)	93, 95	18,874
Commencement Bay (ND)	89, 91, 95, 96	769,089
Elliott Bay (ND)	90, 91, 92, 93, 94, 95, 96, 97	733,631
Port Gardner (ND)	90, 91, 93, 94, 95, 96, 97	1,722,871
Rosario Strait (D)	91, 92, 93, 94, 95, 96	1,074,790
Bellingham Bay (ND)	93, 96	77,683
Port Townsend (D)	93	22,642
Port Angeles (D)	96	22,344
Total cumulative volume		4,441,924
GRAYS HARBOR	**(1996 - 1997)**	
Point Chehalis (D)	96, 97	1,035,591
South Jetty (D)	96, 97	2,633,516
Half Moon Bay (beneficial use site)	96, 97	583,384
3.9 Mile Ocean (D)	not used	
Total cumulative volume		4,252,491

Legend: ND = nondispersive; D = dispersive

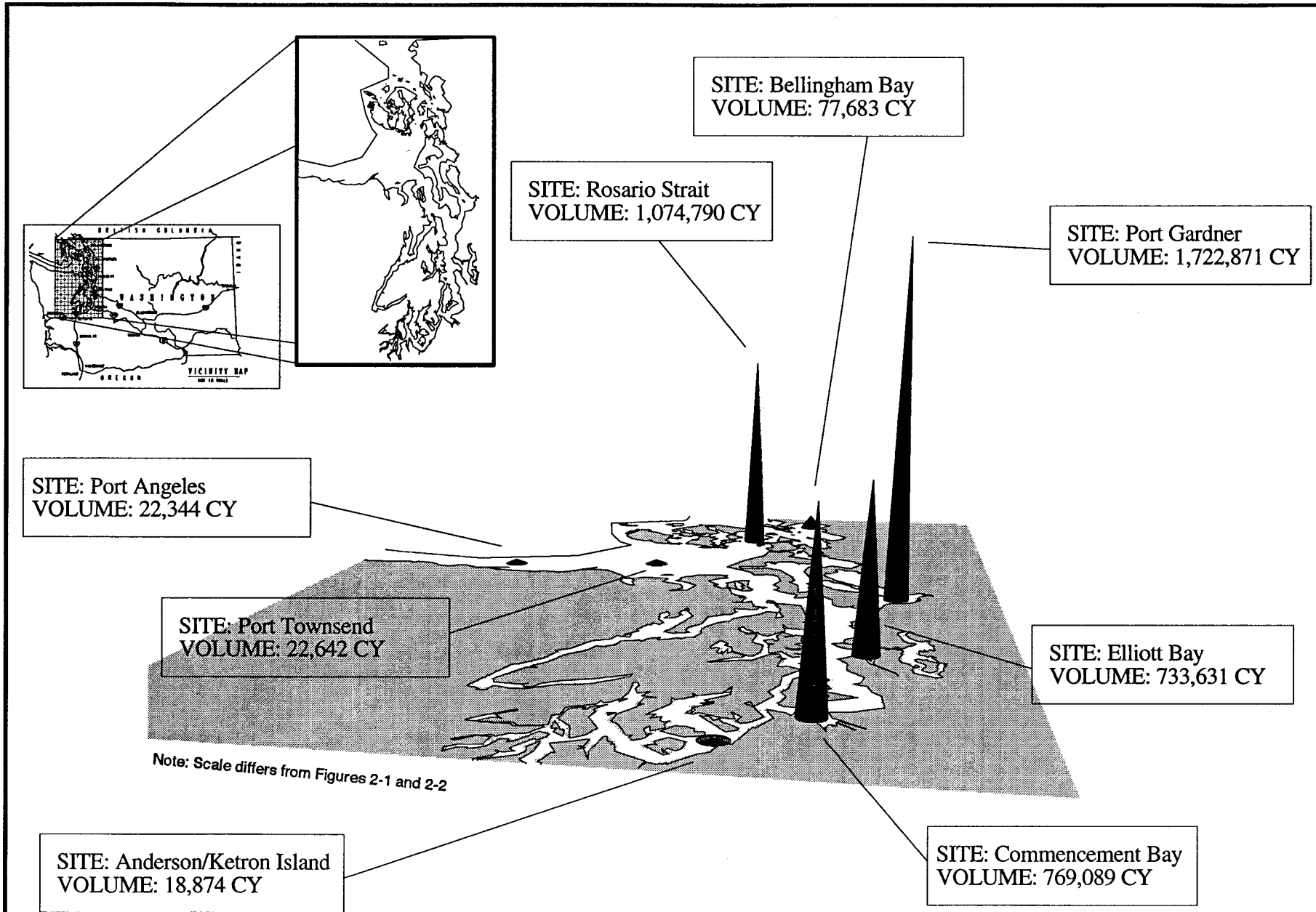

Figure 2-6. PSDDA Cumulative Disposal Volumes in Puget Sound Dredging Years 1989-1997

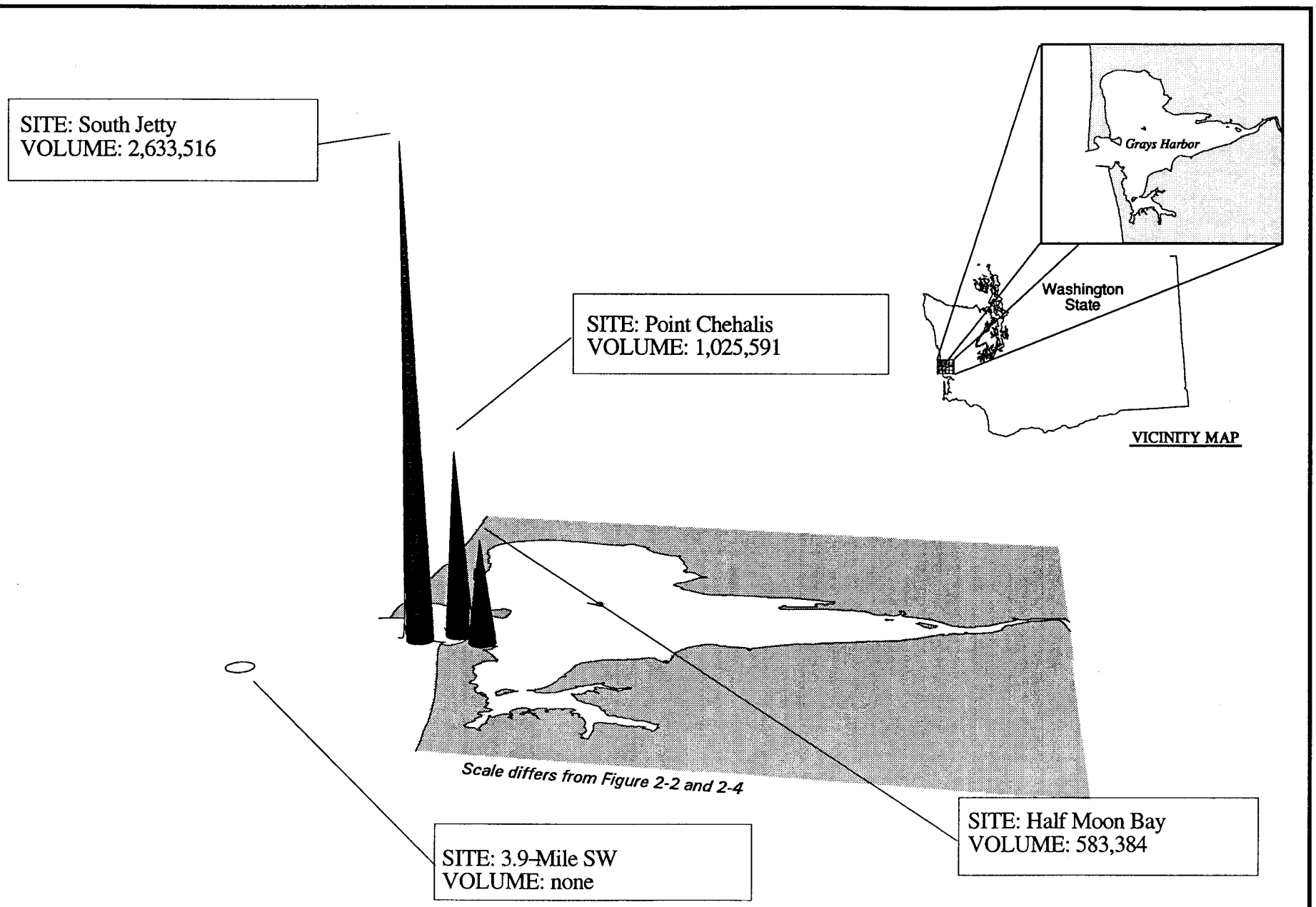

Figure 2-7. Cumulative Disposal Volumes for Grays Harbor (1996-1997)

Table 2-8. Nine Year PSDDA Site Use Summary.

Nondispersive Disposal Site	Cumulative Volumes (CY)	Average Volume (CY/YR)	15-Year Predictions MPR Phase I/II (CY)	Percent of 15-Year Prediction	Estimated Time to Exceed Site Capacity[3] (Years)
Port Gardner (1989-1997)	1,722,871	191,430	8,243,000	20.9	47
Elliott Bay (1989-1997)	733,631	81,515	10,525,000	7.0	>50
Bellingham Bay (1990-1997)	77,683	9,710	1,181,500	6.6	>50
Commencement Bay (1989-1997)	769,089	85,454	3,929,000	19.6	>50
Anderson/Ketron Island (1990-1997)	18,874	2,359	785,000	2.4	>50
SUBTOTALS:	3,322,148	370,468	24,763,500	11.3	N/A
Dispersive Disposal Site	**Cumulative Volumes (CY)**	**Average Volume per Year (CY/YR)**	**15-Year Predictions MPR Phase I/II (CY)**	**Percent of 15-Year Prediction**	**Estimated Time to Exceed Site Capacity[4] (Years)**
Rosario Strait (1990-1997)	1,074,790	134,349	1,801,000	59.7	N/A
Port Townsend (1990-1997)	22,642	2,830	687,000	3.3	N/A
Port Angeles (1990-1997)	22,344	2,793	285,000	7.8	N/A
SUBTOTALS:	1,119,776	139,972	2,773,000	40.4	N/A
GRAND TOTALS:	4,441,924	555,241	27,536,500	16.1	N/A

Table 2-9 lists the completed and scheduled DMMP disposal site monitoring events at the PSDDA nondispersive and dispersive sites. To date, the DMMP agencies have conducted seven post-disposal monitoring surveys at nondispersive sites - 2 full, 2 partial, 2 tiered-full and one tiered-partial monitoring events. Four of five nondispersive sites have been surveyed. The only nondispersive site not yet monitored is the Ketron/Anderson Island site, which has received relatively little use to date.

[3] Site capacity estimated in Phase II Disposal Site Selection Technical Appendix for nondispersive sites is approximately 9,000,000 cubic yards.

[4] Actual site capacity for dispersive sites is not limited, assuming complete dispersal of dredged material off site.

Table 2-9. PSDDA Disposal Site Monitoring Surveys.

Year	Disposal Site	Type of Survey
1990	Port Gardner	Full
1990	Elliott Bay	Partial
1992	Elliott Bay	Full
1993	Bellingham Bay	Partial
1994	Port Gardner	Tiered-Full
1995	Commencement Bay	Tiered-Full
1996	Commencement Bay	Tiered-Partial

Based on PSDDA site monitoring data collected to date (including physical mapping, on and offsite sediment chemistry, sediment toxicity, offsite infaunal bioaccumulation, and offsite benthic community structure data), dredged material disposal is not causing adverse impacts at or adjacent to any of the nondispersive sites. PSDDA evaluation procedures appear to adequately protect the environmental conditions at the disposal sites.

The overall goal of the PSDDA site monitoring program is to insure that the PSDDA prescribed disposal site conditions are maintained and verify that PSDDA dredged material evaluation procedures adequately protect the environment. Monitoring surveys provide positive feedback to verify the adequacy of the PSDDA dredged material management process. Annual review meetings provide a forum to report on these post-disposal survey findings conducted during any given dredging year, and any adjustments to the management plan.

The PSDDA Management Plan Reports (MPR, 1988, 1989) recognize that intensive post-disposal monitoring surveys would be required early in program implementation to gather data on the adequacy of the evaluation procedures to meet the site management objectives. Seven monitoring events to date have not detected unexpected adverse impacts at any of the four nondispersive sites that have been monitored. In accordance with the management plan, following the 1997 SMARM, the DMMP agencies reduced the frequency and scope of monitoring based on past documented compliance with the site management objectives. These modifications to the management plan formally incorporated tiered-full monitoring into the management plan, and initiate monitoring when cumulative volumes approach or exceed 300,000 cubic yards since the last monitoring event. The DMMP agencies will continue to assess the perimeter chemistry evaluation approach adopted and implemented following the 1997 SMARM.

References

DSSTA, 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Phase I (Central Puget Sound) Disposal Site Selection Technical Appendix. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

DSSTA, 1989. Puget Sound Dredged Disposal Analysis (PSDDA) Phase II (North and South Puget Sound) Disposal Site Selection Technical Appendix. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

EPTA, 1988. Evaluation Procedures Technical Appendix. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

FEIS, 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Phase I (Central Puget Sound) Final Environmental Impact Assessment. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

FEIS, 1989. Puget Sound Dredged Disposal Analysis (PSDDA) Phase II (North and South Puget Sound) Final Environmental Impact Assessment. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

Kendall, D. and T. Benson. 1997. Disposal site monitoring chemical valuation guidelines reassessment and proposed changes to nondispersive site management plans. A DMMP Clarification Paper presented at the May 7, 1997 Sediment Management Annual Review Meeting.

MPR, 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Management Plan Report, Unconfined Open-Water Disposal of Dredged Material, Phase I (Central Puget Sound). Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

MPR, 1989. Puget Sound Dredged Disposal Analysis (PSDDA) Management Plan Report, Unconfined Open-Water Disposal of Dredged Material, Phase II (North and South Puget Sound). Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

MPTA, 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Management Plan Technical Appendix. Prepared by the Corps of Engineers in cooperation with the

Environmental Protection Agency, Region 10, and the Washington State Departments of Ecology and Natural Resources.

Pavlou, S.P., R.N. Dexter, W. Hom, A.J. Hafferty, and K.A. Krogslund. Aquatic disposal field investigations Duwamish Waterway disposal site Puget Sound, Washington; Appendix E: Release and distribution of polychlorinated biphenyl's induced by open-water dredged disposal activities. Prepared for the Dredged Material Research Program, Office, Chief of Engineers, U.S. Army Washington, DC (Technical Report: D-77-24).

PTI, 1988. Puget Sound Dredged Disposal Analysis: Baseline Survey of Phase I Disposal Sites. Prepared for Washington Department of Ecology. PTI Environmental Services, Bellevue, WA.

PTI, 1989. Puget Sound Dredged Disposal Analysis: Baseline Survey of Phase II Disposal Sites. Prepared for Washington Department of Ecology. PTI Environmental Services, Bellevue, WA.

SAIC 1991. PSDDA 1991 Monitoring Program: Port Gardner benchmark station observations. Tissue chemistry of invertebrates from Port Gardner and Bellingham Bay, and bioaccumulation guidelines assessment. Draft report. Prepared by SAIC, Bothell, WA. for the Washington State Department of Natural Resources and the PSDDA agencies.

SAIC, 1993 PSDDA perimeter chemistry trigger approach assessment. Prepared by SAIC, Bothell, WA. for the Washington State Department of Natural Resources and the PSDDA agencies.

SAIC, 1995. 1995 full monitoring at the Commencement Bay PSDDA disposal site. Prepared by SAIC, Bothell, WA. for the Washington State Department of Natural Resources and the PSDDA agencies.

SAIC, 1996a. A new statistical protocol for evaluating PSDDA perimeter site chemistry. Prepared by SAIC, Bothell, WA. and Mountain Whisper Light Statistical Consulting, Seattle, WA. for the Washington State Department of Natural Resources and the PSDDA agencies.

SAIC, 1996b. Partial monitoring at the Commencement Bay PSDDA disposal site. Prepared by SAIC, Bothell, WA and Herrera Environmental Consultants, Seattle, WA. for the Washington State Department of Natural Resources and the PSDDA agencies.